



Integrated Chemistry – Physics

Indiana’s academic standards for Integrated Chemistry – Physics contain two standards, The Principles of Integrated Chemistry – Physics and Historical Perspectives of Integrated Chemistry – Physics. Ideas listed underneath each standard build the framework for the Integrated Chemistry – Physics course.

In addition, ideas from the following four supporting themes will enable students to understand that science, mathematics, and technology are interdependent human enterprises, and that scientific knowledge and scientific thinking serve both individual and community purposes.

The Nature of Science and Technology

It is the union of science and technology that forms the scientific endeavor and that makes it so successful. Although each of these human enterprises has a character and history of its own, each is dependent on and reinforces the other. This first theme draws portraits of science and technology that emphasize their roles in the scientific endeavor and reveal some of the similarities and connections between them. In order for students to truly understand the nature of science and technology, they must model the process of scientific investigation through inquiries, fieldwork, lab work, etc. Through these experiences, students will practice designing investigations and experiments, making observations, and formulating theories based on evidence.

Scientific Thinking

There are certain thinking skills associated with science, mathematics, and technology that young people need to develop during their school years. These are mostly, but not exclusively, mathematical and logical skills that are essential tools for both formal and informal learning and for a lifetime of participation in society as a whole. Good communication is also essential in order to both receive and disseminate information and to understand others’ ideas as well as have one’s own ideas understood. Writing, in the form of journals, essays, lab reports, procedural summaries, etc., should be an integral component of students’ experiences in Integrated Chemistry – Physics.

The Mathematical World

Mathematics is essentially a process of thinking that involves building and applying abstract, logically connected networks of ideas. These ideas often arise from the need to solve problems in science, technology, and everyday life – problems ranging from how to model certain aspects of a complex scientific problem to how to balance a checkbook. Students should apply mathematics in scientific contexts and understand that mathematics is a tool used in science to help solve problems, make decisions, and understand the world around them.

Common Themes

Some important themes, such as systems, models, constancy, and change, pervade science, mathematics, and technology and appear over and over again, whether we are looking at ancient civilization, the human body, or a comet. These ideas transcend disciplinary boundaries and prove fruitful in explanation, in theory, in observation, and in design. These themes provide students with opportunities to engage in long-term and ongoing laboratory and fieldwork and to understand the role of change over time in studying concepts in Integrated Chemistry – Physics.



Principles of Integrated Chemistry – Physics

Students begin to conceptualize the general architecture of the atom and the roles played by the main constituents of the atom in determining the properties of materials. They investigate, using such methods as laboratory work, the different properties of matter. They investigate the concepts of relative motion, the action/reaction principle, wave behavior, and the interaction of matter and energy.

Structure and Properties of Matter

- CP.1.1 Understand and explain that atoms have a positive nucleus (consisting of relatively massive positive protons and neutral neutrons) surrounded by negative electrons of much smaller mass, some of which may be lost, gained, or shared when interacting with other atoms.
- CP.1.2 Realize that and explain how a neutral atom's atomic number and mass number can be used to determine the number of protons, neutrons, and electrons that make up an atom.
- CP.1.3 Understand, and give examples to show, that isotopes of the same element have the same numbers of protons and electrons but differ in the numbers of neutrons.
- CP.1.4 Know and explain that physical properties can be used to differentiate among pure substances, solutions, and heterogeneous mixtures.

Changes in Matter

- CP.1.5 Distinguish among chemical and physical changes in matter by identifying characteristics of these changes.
- CP.1.6 Understand and explain how an atom can acquire an unbalanced electrical charge by gaining or losing electrons.
- CP.1.7 Identify the substances gaining and losing electrons in simple oxidation-reduction reactions.
- CP.1.8 Know and explain that the nucleus of a radioactive isotope is unstable and may spontaneously decay, emitting particles and/or electromagnetic radiation.
- CP.1.9 Show how the predictability of the nuclei decay rate allows radioactivity to be used for estimating the age of materials that contain radioactive substances.
- CP.1.10 Understand that the Periodic Table is a listing of elements arranged by increasing atomic number, and use it to predict whether a selected atom would gain, lose, or share electrons as it interacts with other selected atoms.
- CP.1.11 Understand and give examples to show that an enormous variety of biological, chemical, and physical phenomena can be explained by changes in the arrangement and motion of atoms and molecules.
- CP.1.12 Realize and explain that because mass is conserved in chemical reactions, balanced chemical equations must be used to show that atoms are conserved.
- CP.1.13 Explain that the rate of reactions among atoms and molecules depends on how often they encounter one another, which is in turn affected by the concentrations, pressures, and temperatures of the reacting materials.
- CP.1.14 Understand and explain that catalysts are highly effective in encouraging the interaction of other atoms and molecules.



Energy Transformations

- CP.1.15 Understand and explain that whenever the amount of energy in one place or form diminishes, the amount in other places or forms increases by the same amount.
- CP.1.16 Explain that heat energy in a material consists of the disordered motions of its atoms or molecules.
- CP.1.17 Know and explain that transformations of energy usually transform some energy into the form of heat, which dissipates by radiation or conduction into cooler surroundings.
- CP.1.18 Recognize and describe the heat transfer associated with a chemical reaction or a phase change as either exothermic or endothermic, and understand the significance of the distinction.
- CP.1.19 Understand and explain that the energy released whenever heavy nuclei split or light nuclei combine is roughly a million times greater than the energy absorbed or released in a chemical reaction. ($E=mc^2$)
- CP.1.20 Realize and explain that the energy in a system* is the sum of both potential energy and kinetic energy.

* Systems could take different forms. One example would be that of an airplane travelling at Mach 3.

Motion

- CP.1.21 Understand and explain that the change in motion of an object (acceleration) is proportional to the net force applied to the object and inversely proportional to the object's mass. ($a = \frac{F}{m}$)
- CP.1.22 Recognize and explain that whenever one object exerts a force on another, an equal and opposite force is exerted back on it by the other object.
- CP.1.23 Understand and explain that the motion of an object is described by its position, velocity, and acceleration.
- CP.1.24 Recognize and explain that waves are described by their velocity, wavelength, frequency or period, and amplitude.
- CP.1.25 Understand and explain that waves can superpose on one another, bend around corners, reflect off surfaces, be absorbed by materials they enter, and change direction when entering a new material.
- CP.1.26 Realize and explain that all motion is relative to whatever frame of reference is chosen, for there is no absolute motionless frame from which to judge all motion.

Forces of Nature

- CP.1.27 Recognize and describe that gravitational force is an attraction between masses and that the strength of the force is proportional to the masses and decreases rapidly as the square of the distance between the masses increases. ($F = G \frac{m_1 m_2}{r^2}$)
- CP.1.28 Realize and explain that electromagnetic forces acting within and between atoms are vastly stronger than the gravitational forces acting between atoms.
- CP.1.29 Understand and explain that at the atomic level, electric forces between oppositely charged electrons and protons hold atoms and molecules together and thus, are involved in all chemical reactions.



- CP.1.30 Understand and explain that in materials, there are usually equal proportions of positive and negative charges, making the materials as a whole electrically neutral. However, also know that a very small excess or deficit of negative charges will produce noticeable electric forces.
- CP.1.31 Realize and explain that moving electric charges produce magnetic forces, and moving magnets produce electric forces.

Standard 2

Historical Perspectives of Integrated Chemistry – Physics

Students gain understanding of how the scientific enterprise operates through examples of historical events. Through the study of these events, they understand that new ideas are limited by the context in which they are conceived, are often rejected by the scientific establishment, sometimes spring from unexpected findings, and grow or transform slowly through the contributions of many different investigators.

- CP.2.1 Explain that Antoine Lavoisier invented a whole new field of science based on a theory of materials, physical laws, and quantitative methods, with the conservation of matter at its core. Recognize that he persuaded a generation of scientists that his approach accounted for the experimental results better than other chemical systems.
- CP.2.2 Describe how Lavoisier's system for naming substances and describing their reactions contributed to the rapid growth of chemistry by enabling scientists everywhere to share their findings about chemical reactions with one another without ambiguity.
- CP.2.3 Explain that John Dalton's modernization of the ancient Greek ideas of element, atom, compound, and molecule strengthened the new chemistry by providing physical explanations for reactions that could be expressed in quantitative terms.
- CP.2.4 Explain that Isaac Newton created a unified view of force and motion in which motion everywhere in the universe can be explained by the same few rules. Note that his mathematical analysis of gravitational force and motion showed that planetary orbits had to be the very ellipses that Johannes Kepler had demonstrated two generations earlier.
- CP.2.5 Describe that Newton's system was based on the concepts of mass, force, and acceleration, his three laws of motion relating them, and a physical law stating that the force of gravity between any two objects in the universe depends only upon their masses and the distance between them.
- CP.2.6 Explain that the Newtonian model made it possible to account for such diverse phenomena as tides, the orbits of the planets and moons, the motion of falling objects, and Earth's equatorial bulge.
- CP.2.7 Describe that among the surprising ideas of Albert Einstein's special relativity is that nothing can travel faster than the speed of light, which is the same for all observers no matter how they or the light source happen to be moving.
- CP.2.8 Explain that the special theory of relativity is best known for stating that any form of energy has mass, and that matter itself is a form of energy. ($E=mc^2$)



- CP.2.9 Describe that general relativity theory pictures Newton's gravitational force as a distortion of space and time.
- CP.2.10 Explain that Marie and Pierre Curie made radium available to researchers all over the world, increasing the study of radioactivity and leading to the realization that one kind of atom may change into another kind, and so must be made up of smaller parts. Note that these parts were demonstrated by Ernest Rutherford, Niels Bohr, and other scientists to be a small, dense nucleus that contains protons and neutrons and is surrounded by a cloud of electrons.
- CP.2.11 Explain that Rutherford and his colleagues discovered that the heavy radioactive element uranium spontaneously splits itself into a slightly lighter nucleus and a very light helium nucleus.
- CP.2.12 Describe that later, Austrian and German scientists showed that when uranium is struck by neutrons, it splits into two nearly equal parts plus one or two extra neutrons. Note that Lise Meitner, an Austrian physicist, was the first to point out that if these fragments added up to less mass than the original uranium nucleus, then Einstein's special relativity theory predicted that a large amount of energy would be released. Also note that Enrico Fermi, an Italian working with colleagues in the United States, showed that the extra neutrons trigger more fissions and so create a sustained chain reaction in which a prodigious amount of energy is given off.



NOTES

Page 98 | Integrated Chemistry – Physics
Science